THE OHIO JOURNAL OF SCIENCE

VOL. 64 NOVEMBER, 1964 No. 6

SOILS AND THEIR PARENT GEOLOGIC MATERIALS IN PART OF THE UNGLACIATED ALLEGHENY PLATEAU, UPPER OHIO VALLEY, AS INTERPRETED FROM A PIPELINE EXCAVATION[1]

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This paper reports the results of study of the soils, soil parent material, and relevant bedrock along the excavation for a pipeline, which extended for five miles from the northeast corner of section 12, St. Clair Township, to the center of section 27, Middleton Township, Columbiana County, Ohio. These results are correlated with some pedologic and geologic generalizations gathered during the soil survey of Columbiana County.

The study area is in the upper Ohio Basin and is drained by Little Beaver Creek, which flows into the Ohio River at Smiths Ferry, Pennsylvania. Little Beaver Creek has a composite drainage basin. A northern basin, formerly draining to the northeast, was ponded by a very early Pleistocene glacier (Lessig, 1963) and joined with a southern basin to form the present basin of Little Beaver Creek (Stout and Lamborn, 1924: 23–33).

Detailed descriptions of 6 soil profiles, representing soils developed from materials on several subdivisions of the Allegheny Plateau in Ohio, are given. Local subdivisions are the ridgetops, benches, steep slopes, high glacial outwash terraces, and drainageways. The soils and materials were studied as a continuum, and the soil profile sites were selected to illustrate deposition as a result of glaciation even though glaciers did not reach the study area.

The above-mentioned subdivisions in the study area are described as:

1. Ridgetops at 1200 to 1230 ft with mostly shallow soils formed from siltstone of the Pennsylvanian Conemaugh formation (this general level was included in the Harrisburg peneplain by Stout and Lamborn (1924),
2. Benches at 1080 to 1180 ft with mostly deep soils formed from water-laid material called Calcutta Silt (Lessig, 1963), underlain by lower Conemaugh rocks (this general level was included in the Worthington peneplain by Stout and Lamborn (1924)),
3. Steep slopes between ridgetops, benches, terraces, and streams with shallow soils from bedrock on the upper part and deep soils from colluvium on the lower part, and with the underlying bedrocks belonging to both Conemaugh and Allegheny formations,
4. Glacial outwash terraces, with deep soils, belonging to a very early Pleistocene or first glaciation at 930 to 970 ft (Lessig, 1961a), Kansan (?) glaciation at 880 ft (Lessig and Rice, 1962), Illinoian glaciation at 820 ft and Wisconsin glaciation at 770 ft (Lessig, 1961b), and
5. Small drainageways above 960 ft, that are filled by colluvium, and North Fork Little Beaver Creek with its floodplain at 755 ft, with immature soils.

[1]Manuscript received November 8, 1963.

The Calcutta Silt on the benches and the very early Pleistocene glacial outwash on the high terrace were found to have persisted during the span of the Pleistocene, whereas during the same time former valley walls were removed and deep gorges excavated in bedrock. Some layers of sandstone, black shale, and weathered material from limestone, coal, and red shale were found to extend into unconsolidated materials.

The soils formed from various juxtaposed parent materials, range from Inceptisols (Sols Bruns Acides) to Alfisols (Gray-Brown Podsolic soils), Ultisols (Red-Yellow Podsolic soils) and intergrades between Alfisols and Ultisols (Soil Survey Staff, 1960). Entisols (Alluvial soils) are found along drainageways.

METHODS

Variations in soil morphology, parent material, and bedrock were observed, identified, and noted during examination of the exposed vertical section of the ditch throughout its length. The vertical arrangement of the soil horizons and other materials was plotted on cross-section paper and the lateral extent of materials and soils along the ditch was mapped on aerial photographs. Soil profiles were described at typical locations and some were sampled for laboratory analysis. The colors and consistence given are for soils in a moist state. The descriptions were made according to the Soil Survey Manual (Soil Survey Staff, 1951) with the following exceptions:

1. The quantities of rock fragments are expressed as percentages by volume.
2. Where rock identification is given, the rocks were identified visually by using a hand lens.
3. Coatings and stains on ped faces were described in terms of estimated thickness and texture, and in terms of color according to Munsell color system notations.
4. Horizon designations and classification of soils were made according to definitions given in Soil Classification, A Comprehensive System, 7th Approximation (Soil Survey Staff, 1960).

The laboratory analyses of the soils were made by the Ohio Agricultural Experiment Station. Mechanical analyses were by the method of Kilmer and Alexander (1949). Exchangeable bases were extracted with normal NH_4Ac by the method of Bray and Wilhite (1929). In this extract, potassium was determined by flame photometry using a Beckman flame photometer. The calcium and magnesium were determined by EDTA photometric titration by the method of Shapiro and Brannock (1956). Exchangeable acidity was determined by the method of Mehlich (1948).

Exchangeable acidity, calcium, magnesium, and potassium were added to obtain the sum of exchangeable cations, which was divided into the sum of the bases and multiplied by 100 to obtain the percentage base saturation. The results of these analyses are shown in table 1.

The soil series names used below are tentatively correlated. These names, except for the Leadvale, are reasonably certain.

RESULTS

Soils and Parent Materials on the Ridgetops

The ridgetops are part of a land surface called the Harrisburg Peneplain by Stout and Lamborn (1924), which is the most extensive, gently sloping to sloping land surface of the region. The ridgetop crossed by the pipeline is at 1200 to 1230 ft in elevation, but some ridgetops rise to 1280 ft a few miles away. There are some monadnocks about 10 miles to the southwest which rise to as high as 1447 ft.

The ridgetops are mantled mostly by shallow Montevallo soils which are formed from a weathered olive-colored siltstone and have solums dominated by coarse fragments or B horizons, with no clay accumulation, less than 8 in. thick. Other

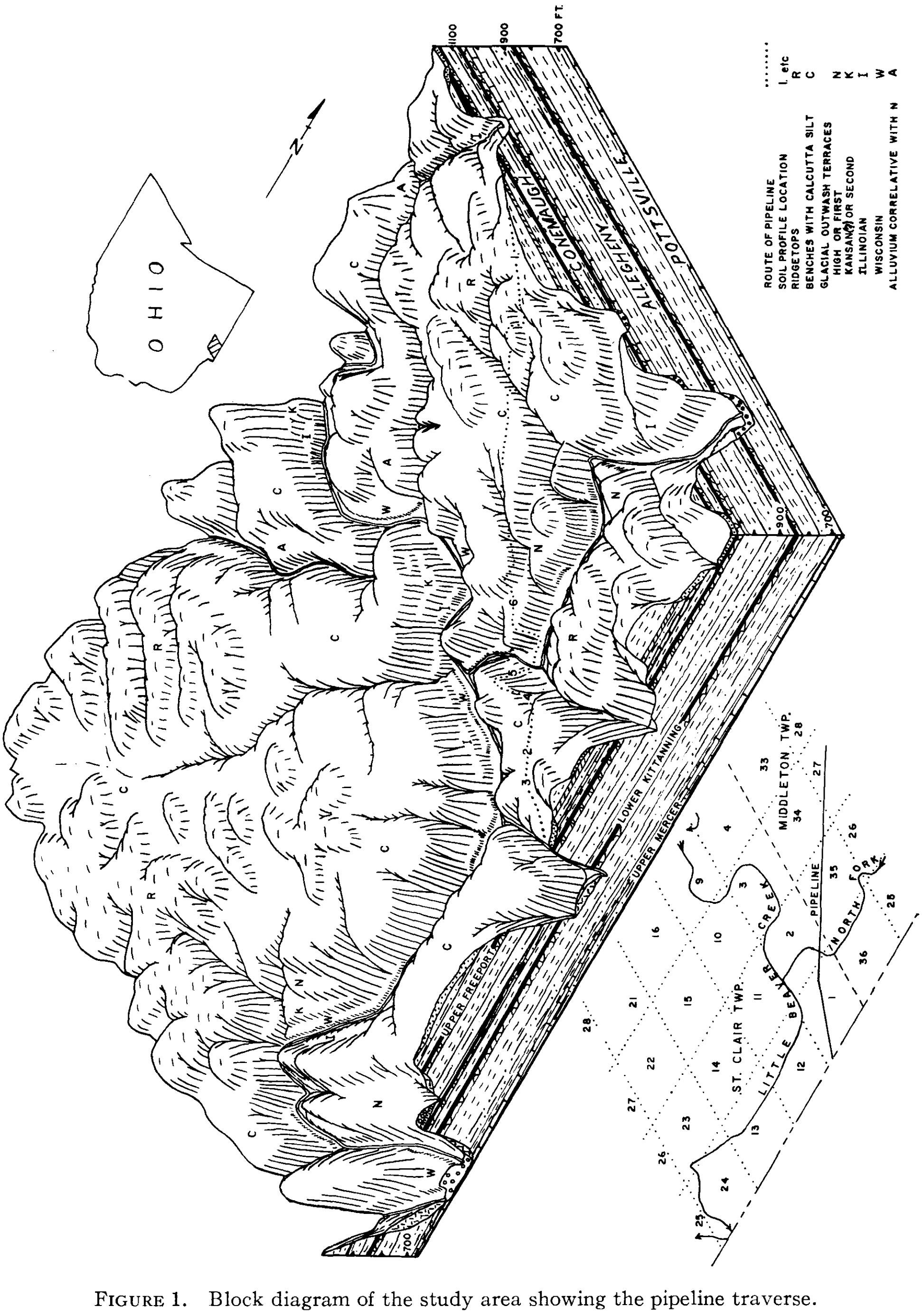

FIGURE 1. Block diagram of the study area showing the pipeline traverse.

less extensive soils on the ridgetops are the shallow Muskingum and the moderately deep Wellston with non-skeletal (less than half composed of fragments) solums, also developed from the siltstone, and the moderately shallow Dekalb developed from sandstone. Deep soils on the ridgetops are formed only where black shale, red shale, and limestone crop out.

The ridgetop crossed by the pipeline is 1300 ft wide and is mantled by Montevallo soils. Following is a description of the Montevallo profile in the northeast corner of the SE¼ section 27, Middleton Township, at 1200-ft elevation (Profile 1 in figs. 1 and 2).

Profile 1.—Description of Montevallo channery silt loam

Horizon and depth	Profile description
A_p	0 to 8 in., very dark grayish brown (10YR 3/2) channery silt loam; weak fine subangular blocky structure; friable; siltstone fragments 15 per cent; neutral (field limed); abrupt smooth boundary.
B_{21}	8 to 11 in., brown (10YR 4/3) channery silt loam; moderate medium and fine subangular blocky structure; friable; roots abundant; siltstone fragments 20 per cent; slightly acid (field limed); gradual boundary.
B_{22}	11 to 15 in., yellowish brown (10YR 5/4) channery silt loam; weak medium angular blocky structure; friable; roots common; siltstone fragments 50 per cent which crush easily; very strongly acid; gradual smooth boundary.
R_1	15 to 19 in., layers of olive brown (2.5Y 4/4) siltstone 10 to 20 mm thick with 2- to 5-mm thick yellowish brown (10YR 5/4) silt loam coatings in cracks; very strongly acid; gradual smooth boundary.
R_2	19 to 60 in., olive (5Y 4/4) oxidized siltstone bedrock with 1 mm-thick yellowish brown (10YR 5/4) loam coatings in cracks; roots common to occasional in cracks to 60 in. depth. The unoxidized siltstone is gray at about 10 ft depth.

The B_{21} and B_{22} horizons of this profile are cambic (color B) horizons (Soil Survey Staff, 1960). Combined, they are less than 8 in. thick and have increases of total clay of only 2.8 per cent and of fine clay of 0.5 per cent over that of the A_p horizon (table 1). The higher clay contents reported for the R_1 and R_2 horizons are due to sampling methods. In these horizons the samples were obtained by scraping the coatings from the rock fragments. The presence of a cambic horizon with a base saturation of 34 to 42 per cent (table 1) has led me to classify this soil as an Inceptisol. The Muskingum and Dekalb soils have morphologies similar to the Montevallo and are also Inceptisols.

Over 20,000 acres of these soils have been mapped on gently sloping to sloping ridgetops in Columbiana County. Their morphologies are unusually consistent, varying only in the amounts of rock fragments and sand, and a few inches in the thickness of the cambic horizon. Of six other Montevallo profiles sampled in the county, several show some evidence of clay increase in the cambic horizon. None, however, have a suitable amount of clay coatings or a sufficient increase in fine clay content to be considered argillic (textural B) horizons. Base data obtained for one other of these six profiles show a maximum base saturation value of 31 per cent.

The ridgetops on which these soils occur are part of the Harrisburg peneplain according to Stout and Lamborn (1924), the oldest erosion surface recognized in the county. Why so little soil material has accumulated from the weathering of the siltstone bedrock is unknown. There is evidence that this soil has not been extensively eroded during or since Pleistocene time in that deep soils remain on benches and on some narrow spurs on the general level only 40 to 100 ft below the ridgetop level.

Soils and Parent Materials on the Benches

The benches occur at a level of 1080 to 1180 ft in elevation in Columbiana County and have been called the Worthington Peneplain by Stout and Lamborn (1924). During soil survey work, this level was found to be mostly mantled by Calcutta Silt, a water-laid deposit, 2 to 10 ft thick, which accumulated in a very early Pleistocene pro-glacial lake (Lessig, 1963). The features at this general level are called benches rather than terraces because the Calcutta Silt is not thick enough to alter the surface formed by the underlying bedrock.

The pipeline crossed 3 of these benches. They are 40 to 100 ft below the bordering ridgetops and, while the soils are generally formed from Calcutta Silt, there are places where the silt is thin or lacking and the soils are formed from underlying bedrock. In some other places, colluvium covers the Calcutta Silt and the soils are formed from colluvium.

The Calcutta Silt is laminated silty material which contains a few sandy and clayey layers, scattered small flat pebbles, and in places a basal unit of gravel from local rocks. It is mapped on about 11,000 acres on the benches. Well-drained Profile 2 and imperfectly drained Profile 3, formed from Calcutta Silt, were studied on the bench located in the northern part of the SE¼ section 1, St. Clair Township (fig. 1). Profile 2 is on a six per cent slope, at an elevation of 1110 ft, located about 300 ft east of a farmhouse and 100 ft north of County Road 434. The lower part of Profile 2 is a buried paleosol formed from sandstone bedrock.

Profile 2.—Description of Holston silt loam, a well-drained soil

Horizon and depth	Profile description
A_p	0 to 8 in., brown (10YR 4/3) silt loam; weak fine granular structure; friable; few small siltstone pebbles; slightly acid (field limed); abrupt smooth boundary.
B_{21t}	8 to 24 in., yellowish brown (10YR 5/6) silt loam; moderate coarse subangular blocky structure; friable; roots common; few small rotted siltstone pebbles; very strongly acid; abrupt smooth boundary.
B_{22xt}	24 to 40 in., dark brown (7.5YR 4/4) fine silt loam with few coarse very pale brown (10YR 7/4) stains; weak fragipan with weak coarse prismatic structure; pale brown (10YR 6/3) clay coats on ped faces; firm; rotted siltstone pebbles 5 per cent, lower part is laminated; very strongly acid; abrupt smooth boundary. Lower part of the Calcutta Silt.
IIA_b	40 to 46 in., brown (10YR 4/3) silt loam; massive or perhaps former structure is obscure; friable; few sandstone fragments; very strongly acid; abrupt smooth boundary. Upper part of buried paleosol developed in underlying bedrock.
IIB_{2b}	46 to 64 in., dark yellowish brown (10YR 4/4) loam; weak medium subangular blocky structure; friable; many sandstone fragments; very strongly acid; clear wavy boundary.
IIR	Below 64 in., yellowish brown (10YR 5/4) sandstone bedrock which is soft and weathered in its upper part but is gray and hard at greater depths.

This Holston soil, at 0 to 40 in., has an ochric epipedon (light colored A horizon), an argillic (textural B) horizon with a high chroma and a fragipan. Profile 2 was not sampled for laboratory analysis because the parent Calcutta Silt is thicker at nine other study sites of this soil series not in the pipeline traverse. Base analysis was performed on one of these other profiles. The base saturation increases from 20 in the upper B horizon to 60 per cent in the lower B, but a yet lower part of the B horizon has fragments of plinthite, yellowish red color and a declining percentage of base saturation. These properties suggest that an Alfisol has formed in a former Ultisol. I classify this soil series as an Alfisol-Ultisol intergrade (Lessig, 1963).

The buried paleosol of Profile 2, at 40 to 64 in., developed from sandstone bedrock, was buried by Calcutta Silt during very early Pleistocene flooding as at Warnock (Lessig, 1959a). At most other Calcutta Silt study sites, the pre-Pleistocene soil was disrupted during flooding, as at the site of Profile 3.

Profile 3 is located about 500 ft to the southeast of Profile 2 on a 700-ft-long 6 per cent slope, about 200 ft from the crest, at an elevation of 1120 ft. It is in the northeast corner of the SE¼ section 1, St. Clair Township (fig. 1).

Profile 3.—Description of Tyler silt loam, an imperfectly drained soil

Horizon and depth	Profile description
A_p	0 to 10 in., dark grayish brown (10YR 4/2) silt loam; weak fine granular structure; friable; few small siltstone pebbles; slightly acid (field limed); abrupt smooth boundary. About 30 ft from this profile this horizon is formed in a colluvium of sandstone material which lays over the soil formed in Calcutta Silt.
B_{1t}	10 to 13 in., brown (10YR 5/3) silt loam; weak coarse platy structure; dark grayish brown (10YR 4/2) coats on ped faces; friable; roots abundant; very few small rotted siltstone pebbles; very strongly acid; abrupt smooth boundary.
B_{21gt}	13 to 20 in., reddish brown (5YR 4/4) silty clay loam with many medium distinct brown (7.5YR 4/2) mottles; strong coarse angular and subangular blocky structure; brown (10YR 5/3) coats on ped faces; firm; roots common; few small rotted siltstone pebbles; very strongly acid; abrupt smooth boundary.
B_{22gxt}	20 to 35 in., dark brown (7.5YR 4/4) silty clay loam ranging to strong brown (7.5YR 5/8) in lower part, many medium prominent light gray (10YR 7/2) mottles; strong fragipan with weak very coarse prismatic structure breaking to strong coarse angular blocky peds; 1- to 5-mm thick dark grayish brown (10YR 4/2) silty clay coats on ped faces; very firm; roots common on prism faces; few pebbles, material is laminated; very strongly acid; gradual smooth boundary.
B_{23gxt}	35 to 43 in., dark brown (7.5YR 4/4) fine silt loam with few medium distinct grayish brown (10YR 5/2) mottles; weak fragipan with moderate coarse prismatic structure breaking to moderate thick platy peds along laminae; 2-mm thick gray (10YR 6/1) clay coats on prism faces, thin dark reddish brown (5YR 3/4) clay coats on laminae; firm; no roots; few rotted siltstone pebbles; very strongly acid; gradual smooth boundary.
B_{24t}	43 to 61 in., dark brown (7.5YR 4/4) silt loam with few coarse black Mn stains; weak coarse prismatic structure breaking to moderate very coarse angular blocky peds; 3-mm thick dark brown (10YR 4/3) silty clay coats on prism faces, thin reddish brown (5YR 4/4) clay coats on laminae; friable; few small iron concretions, material is well laminated; very strongly acid; abrupt smooth boundary.
IIR	61 in. and below, gray sandstone bedrock; soft in upper part, becomes harder with depth.

This Tyler profile has an ochric epipedon, grayish mottles and coatings in part of the argillic horizon between 10 and 43 in., and a fragipan. The base saturation increases with depth from 41 to 58 per cent (table 1). These properties are characteristic of Alfisols. It occurs rather high on the landscape to be imperfectly drained, so this morphology may be relict, as at a site near Calcutta (Lessig, 1963: 131-132). The colluvium occurring 30 ft from Profile 3 and over the Calcutta Silt apparently originated from a sandstone layer higher on the slope (figs. 1 and 2).

Warped black shale in a layer a foot thick extends horizontally into the Caltcuta Silt for a distance of 20 ft (NE¼ section 34, Middleton Twp.) (fig. 2) from a hill of bedrock rising above the Calcutta Silt flat. There is less than 40 ft of bedrock on the hill above the tongue level, and this seems too small a load to extrude a shale tongue. No clues were found to indicate how this took place. The phenomenon is mentioned here as part of the description of materials on the benches. Similar tongues have been recognized at other types of sites and are reported later.

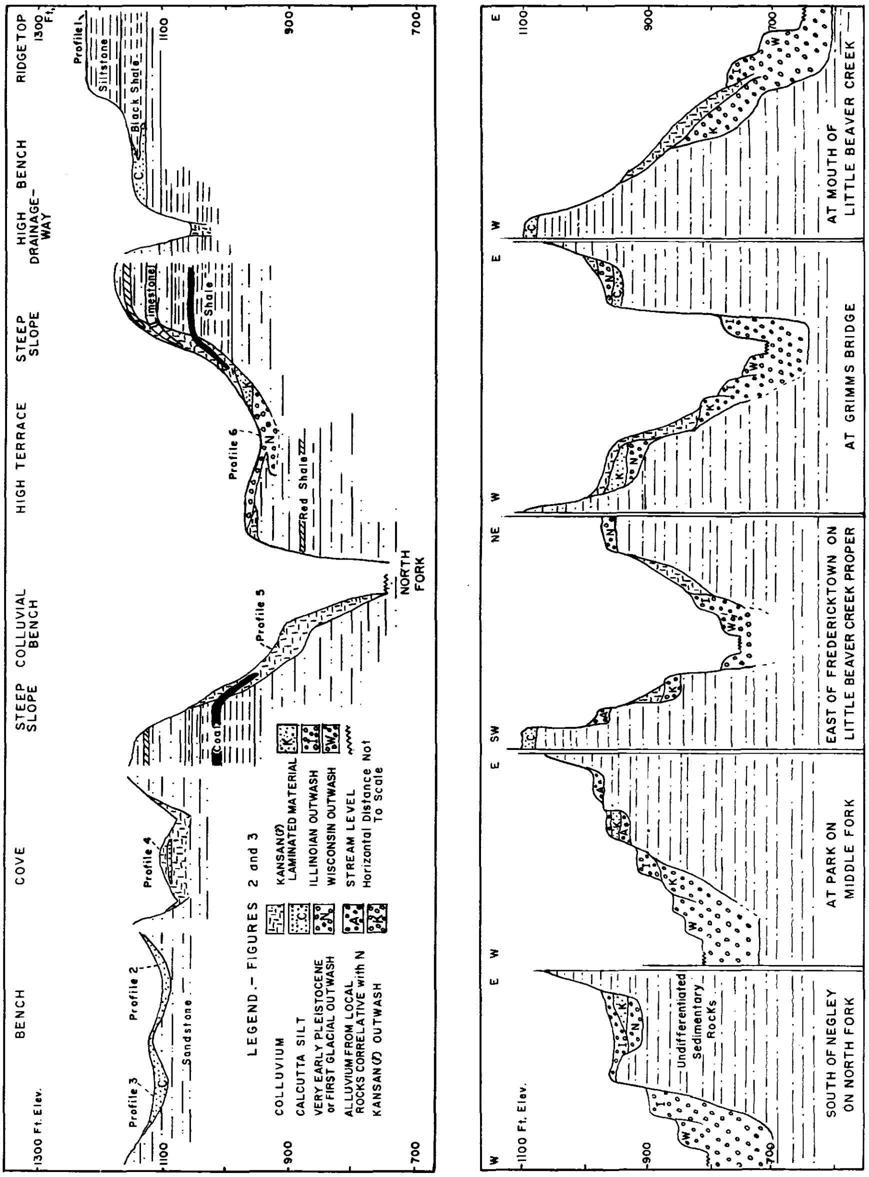

FIGURE 2. Sections along the pipeline traverse showing where the soil profiles described occur. Looking south.

FIGURE 3. Sections at various places along Little Beaver Creek showing arrangement and positions of Pleistocene deposits. Looking upstream.

Study of soils along the pipeline and elsewhere in the unglaciated part of the county reveals that remnants of Calcutta Silt and other unconsolidated soil material have persisted on bench and terrace surfaces during the time in which land masses as much as 300 ft thick and a half mile wide have been removed by lateral and downward stream corrasion. Some Calcutta Silt materials now occur on spurs only a few hundred feet wide.

Soils and Parent Materials on the Steep Slopes

Ten steep and very steep (20 to 50 per cent) slopes were crossed by the pipeline. These slopes are 600 to 1300 ft long, with crests as high as 1180 ft and bases as low as 755 ft. Other steep slopes are shorter and have less relief. The uppermost parts have shallow soils developed in underlying bedrock which are similar to Profile 1. The midslopes have shallow and moderately deep soils developed in colluvium that is 1 to 4 ft thick. Where beds of coal, limestone, or red shale crop out, the weathered outcrop extends 20 to 60 ft downhill with colluvium both below and above the outcrop (fig. 2). These thin rock layers thus have a proportionately extensive influence on the composition of soil material on slopes. Coves and lower slopes have deep soils developed in colluvium ranging from 10 to more than 30 ft thick.

A well-drained soil (Profile 4) and a moderately well-drained soil (Profile 5) developed in colluvium were studied. The well-drained soil occurs on an interfluve high in a cove (figs. 1 and 2) at 1110-ft elevation, in the northeast corner of SW¼ section 1, St. Clair Township.

Profile 4.—Description of a well drained soil formed in colluvium

Horizon and depth	Profile description
A_1	0 to 3 in., black (10YR 2/1) to very dark grayish brown (10YR 3/2) loam; weak coarse and fine crumb structure; very friable; roots abundant; sandstone fragments 15 per cent; very strongly acid; abrupt smooth boundary.
B_{21}	3 to 26 in., yellowish brown (10YR 5/4) channery loam to sandy loam; weak fine subangular blocky structure; friable; roots abundant ranging to common in lower part; sandstone fragments 20 per cent; very strongly acid; clear smooth boundary.
B_{22}	26 to 32 in., yellowish brown (10YR 5/4) channery sandy loam with few medium very pale brown (10YR 7/4) stains and dark grayish brown (10YR 4/2) mottles; weak fine subangular blocky structure; friable; roots occasional; sandstone fragments 25 per cent; very strongly acid; gradual wavy boundary.
B_{23xg}	32 to 38 in., coarsely mottled yellowish brown (10YR 5/4) and dark grayish brown (10YR 4/2) channery loam; weak fragipan with weak medium subangular blocky structure; firm in position; roots occasional; sandstone fragments 25 per cent; very strongly acid; clear smooth boundary.
IIB_{24xg}	38 to 51 in., dark grayish brown (10YR 4/2) loam with common coarse gray (N 5/) mottles and light yellowish brown (10YR 6/4) stains; fragipan with strong very coarse prismatic structure breaking to strong coarse angular blocky peds; very firm; roots occasional; material is laminated but contains 5 per cent sandstone fragments; very strongly acid; abrupt smooth boundary. This layer is like and lies at the same elevation as the Calcutta Silt.
IIIC	51 to 60 in., rotted sandstone fragments and sandy soil material; single grain structure; noncoherent; strongly acid. Colluvium appears to be quite thick below 60-in. depth. Bedrock was not found beneath small drainageways on either side of site.

This soil has a cambic horizon and a fragipan. The percentage base saturation declines in the IIB_{24xg} horizon (table 1). The soil is an Inceptisol. The increase in clay content in the B_{21} horizon (table 1) is not great enough to qualify this horizon as being argillic. The clay increase in the IIB_{24xg} horizon is attributed to the lithologic discontinuity—the layer of laminated silty material. This horizon is underlain by colluvium.

The sandstone fragments, in the horizons other than the IIB_{24xg}, are arranged at angles to each other, or are not oriented, and the soil material is not sorted. The material of these other horizons and others like it are identified as colluvium in this report. Apparently the laminated IIB_{24xg} horizon was deposited after some colluvial deposition and was buried by later colluvial deposition. Thin water-laid layers are found within colluvium at lower elevations also, as at Vulcan (Lessig, 1961a) and in California Hollow at East Liverpool, where excavation for a new highway enabled study of a colluvial deposit for a distance of 2 miles.

Deep colluvium occurs further down the slopes on a terrace-like colluvial bench about 100 to 150 ft above drainage along Little Beaver Creek south of the Illinoian till sheet boundary (figs. 2, 3 and 4) and along the Ohio Valley where colluvium buries a Kansan (?) (second) glacial outwash (Lessig, 1959c). Where the pipeline crossed the colluvial bench, the excavation was not deep enough to reveal whether or not buried outwash is present beneath the colluvium. Profile 5 (fig. 2), formed in the colluvium here, is moderately well drained, on a 1300-ft-long 27 per cent slope, at 870-ft elevation, 900 ft from the crest of the slope. It is located in the southwest corner of the NW¼ section 1, St. Clair Township, about 200 ft southeast of railroad track (fig. 1).

Profile 5.—Description of Leadvale[1] channery silt loam

Horizon and depth	Profile description
A_1	0 to 3 inches, very dark brown (10YR 2/2) channery silt loam; weak fine granular structure; very friable; sandstone fragments 50 per cent; very strongly acid; abrupt wavy boundary.
A_2	3 to 9 in., yellowish brown (10YR 5/4) channery silt loam; weak fine granular structure; friable; sandstone fragments 50 per cent; very strongly acid; abrupt smooth boundary.
B_{21t}	9 to 21 in., dark yellowish brown (10YR 4/4) and brown (10YR 4/3) channery fine silt loam; weak coarse to medium subangular blocky structure; friable; sandstone fragments 40 per cent; very strongly acid; clear smooth boundary.
B_{22xgt}	21 to 40 in., mottled brown (10YR 4/3), gray (10YR 5/1) and yellowish brown (10YR 5/4) channery loam; fragipan with weak very coarse subangular blocky structure; firm; sandstone fragments 50 per cent; very strongly acid.
B_{23xg}	40 to 84 in., dark brown (10YR 3/3) shaly loam; fragipan with moderate coarse subangular blocky structure; very thin dark gray (10YR 4/1) clay coats on ped faces; less firm than B_{22xgt}; black shale fragments 25 per cent and a few sandstones; very strongly acid.
C_1	84 to 120 in., dark brown (7.5YR 3/2) shaly sandy loam with common coarse black Mn stains; massive; firm in position; black shale fragments 35 per cent and a few sandstones; strongly acid.
C_2	120 to 132 in., very dark brown (10YR 2/2) shaly silt loam to loam; massive; very firm; black shale fragments 25 per cent and a few sandstones; neutral.
IIC_3	Below 132 in., dark grayish brown (10YR 4/2) laminated silty alluvium containing fragments of black shale, sandstone and siltstone.

This soil has an ochric epipedon, an argillic horizon, and a thick mottled fragipan. It was not sampled for laboratory analysis, but all other moderately well-drained profiles in the county which have been tested, including seven formed in pre-Wisconsin-aged material, have base saturations of above 35 per cent in the

[1]Correlation of the name Leadvale is not certain.

B horizon and increasing values with depth. It is assumed that this profile has similar base properties and otherwise fits the Alfisols classification.

Apparently the thick colluvium was deposited chiefly in pre-Illinoian times because it was not found on the Illinoian till plain. The Illinoian till plain was carefully studied along the pipeline excavation, but is not reported here.

Soils and Parent Materials on the High Terrace

The pipeline traversed a 1600-ft-wide terrace, at 930 to 970 ft in elevation, on the west side of North Fork Little Beaver Creek. The terrace is situated about 200 ft above the creek. It is mantled chiefly by very early Pleistocene glacial outwash, but other materials are found over and under the outwash. The terrace is highest near its escarpment and here a buried paleosol formed from colluvium containing red clay shale material is buried by the outwash (fig. 2). This colluvium must have originated on a former east valley wall that existed in the position now occupied by the gorge of North Fork—the valley wall, a rock mass half a mile wide and 200 ft thick, apparently being long since removed by lateral and downward stream corrasion. The colluvium beneath the outwash is a relic from the extinct valley wall and must predate the outwash. At other study sites, Calcutta Silt is buried by this outwash (Lessig, 1963).

The terrace slopes downward towards the west valley wall. Where the pipeline crossed part of this slope, a layer of sandstone, 1 ft thick, extends horizontally into the outwash (fig. 2) in much the same manner as the black shale extends into the Calcutta Silt, as noted in the paragraph following the discussion of Profile 3. No clues were found which indicated how these bedrock extensions took place.

Near the west valley wall where the terrace is below 960 ft in elevation, part of the strongly weathered, extremely acid outwash is buried by laminated silt and silty clay, which are in turn buried by 2 ft of colluvium (fig. 2). The soil in the colluvium and laminated material is imperfectly drained, has a fragipan, a thick argillic horizon, and soil structure to a depth of 7 ft. It is leached to a depth of 8 ft. The materials occur here in the same sequence as they do near Vulcan and Wellsville (fig. 4) in the Ohio Valley (Lessig, 1961a). Their arrangement indicates a long period of weathering and soil formation in the very early Pleistocene outwash, with later burial by laminated material during ponding and deposition of colluvium over the laminated material. Following this, part of the colluvium and laminated material were eroded so that part of the very early Pleistocene outwash below 960 ft was exhumed and partly eroded, and soil was developed in the exhumed outwash.

The higher part of the terrace at 960 to 970 ft has a yellowish-red well-drained soil formed in outwash that is only 4 ft thick. The exhumed outwash below 960 ft is over 13 ft thick and offered opportunity to study soil development in thick outwash. However, the soil is thinner here than in the Ohio Valley (Lessig, 1961a), because its period of formation was shorter. The soil is described at a point about 250 ft east of the road in the northwest corner of NE¼ section 2, St. Clair Township. It is on a 3 per cent convex slope on a low narrow interfluve.

Profile 6.—Description of Parke silt loam

Horizon and depth	Profile description
A_p	0 to 10 in., brown (10YR 4/3) silt loam ranging horizontally to gravelly loam; weak fine granular structure; friable; neutral (field limed); abrupt smooth boundary.
B_{21t}	10 to 23 in., yellowish brown (10YR 5/6) ranging to strong brown (7.5YR 5/6) silt loam; moderate medium subangular ranging to fine angular blocky structure; friable; pebbles 10 per cent; extremely acid; gradual smooth boundary.

B_{22t} 23 to 32 in., yellowish red (5YR 5/8) gravelly sandy loam; weak medium subangular blocky structure; firm in position, friable when disturbed; pebbles 75 per cent; extremely acid; gradual smooth boundary.

B_{23} 32 to 50 in., reddish brown (5YR 4/4) gravelly sandy loam; weak coarse subangular blocky structure; firm in position, friable when disturbed; pebbles 50 per cent; extremely acid; gradual smooth boundary.

B_{24} 50 to 62 in., dark brown (7.5YR 4/4) gravelly sandy loam with coarse distinct pinkish gray (7.5YR 6/2) mottles; weak coarse subangular blocky structure; thick brown (7.5YR 4/2) clay coats on ped faces and pebbles; friable; pebbles 50 per cent; extremely acid; gradual smooth boundary.

B_3 62 to 156 in., reddish brown (5YR 4/4) gravelly sandy loam; single grain structure; pebbles 30 per cent; extremely acid. Pebble count of 400 pebbles at 156-in. depth: rotted sandstone 57 per cent, siltstone 13 per cent, concretions and fragments of plinthite 16 per cent, quartzite 5 per cent; rotted chert 2 per cent, unidentified ghosts 7 per cent.

This soil has an ochric epipedon and an argillic horizon at 10 to 23 in. However, the percentage of fine clay remains high in the horizons between 23 and 70 in. and clay coats pebbles and ped faces to 62 in. The B_{22} horizon has a chroma of 8 in the 5YR hue, the base saturation declines below 35 per cent with depth, and the calcium-magnesium ratio declines with depth (table 1). These properties fit those of the Ultisols. The Parke series, where formed from very early Pleistocene glacial outwash, was studied at five other sites in the county. The solum is a few feet thicker at these other sites and the argillic horizons are as much as 40 in. thicker (Lessig, 1961a). Profile 6 is believed to be decapitated because of its thinner argillic horizon and its situation. The parent material of the Parke series, at the low level reservoir excavation in East Liverpool, has hard continuous plinthite formed in the glacial outwash at depths of 20 to 25 ft (Lessig, 1963: 137). Fragments of plinthite were found in the solums at several sites. Apparently modern soil-forming processes are decomposing former continuous plinthite.

Small bodies of colluvium, a residue, remain on the outwash near Profile 6.

The morphology of moderately well drained soil formed in the outwash on this terrace remnant has been studied and found to be like Alfisols (Gray-Brown Podsolic) soils (Lessig, 1961a), but the soil has not been analyzed for cations.

This high terrace is the highest, most deeply weathered, and oldest of 4 levels of glacial outwash in the upper Ohio drainage basin. I interpret this outwash as belonging to the first (very early Pleistocene) glaciation to invade the Allegheny Plateau (Lessig, 1961a), and the laminated material as a deposit during ponding by a Kansan (?) glacier.

Lower Glacial Outwash Terraces along Little Beaver Creek

Remnants of a lower level of glacial outwash belonging to a Kansan (?) or second glaciation are found along Little Beaver Creek between Elkton (fig. 4) (Lessig and Rice, 1962) and East Liverpool (Lessig, 1959c), and at Globe Hill (Lessig, 1959a) in the Ohio Valley. At most places it is buried by colluvium. There are also remnants of two yet lower levels of outwash attributed to the Illinoian and Wisconsin glaciations (Lessig, 1961b). No colluvium was found over these lowest outwashes.

The soil materials of these terraces are comparatively less weathered than those of the very early Pleistocene outwash. These younger terraces are not present at the point where the pipeline crossed Little Beaver Gorge, but were studied elsewhere. Their study shows that the soils formed from Wisconsin outwash are Alfisols and the well-drained soils from Illinoian and Kansan (?) outwash are Ultisols.

Soil Materials in the Drainageways

The pipeline crossed North Fork Little Beaver Creek at an elevation of 755 ft (fig. 2). The creek flows over sandstone bedrock here and has a flood plain 300-ft wide which is covered by more than 5 ft of alluvium. Entisols are formed in the alluvium. Well borings in Fredericktown indicate that the bedrock is entrenched beneath the stream level and that the sandstone cropping out in the creek is local.

TABLE 1

Laboratory data for profiles of various soil orders occuring in the pipeline traverse

Depth in inches	Horizon	Particle size distribution (in mm) (percent) very coarse and coarse sand 2–.5	medium to very fine sand .5–.05	silt .05–.002	total <.002	fine <.0002	pH	Exchangeable cations ME/100 g H	Ca	Mg	K	Base saturation per cent	Calcium magnesium ratio
Profile 1, Inceptisol													
0–8	A_p	8.4	15.7	63.8	12.1	0.9	7.0	5.2	7.6	4.9	0.72	72	1.5
8–11	B_{21}	7.8	9.9	67.4	14.9	1.4	5.9	6.2	2.6	1.4	0.46	42	1.9
11–15	B_{22}	16.2	10.8	58.2	14.8	1.1	4.9	6.4	1.4	1.5	0.28	34	0.9
15–19	R_1	15.9	10.9	55.0	18.2[1]	1.1	4.9	6.4	2.0	1.4	0.23	36	1.4
19–30	R_2	19.8	16.8	46.8	16.6[1]	1.7	4.9	7.5	2.9	2.2	0.26	42	1.3
Profile 3, Alfisol													
0–10	A_p	4.8	11.5	68.5	15.2	1.4	6.1	6.6	5.0	3.7	0.37	58	1.4
10–13	B_{1t}	2.4	7.1	69.4	21.1	7.4	4.7	8.2	4.1	1.2	0.31	41	3.4
13–20	B_{21gt}	0.7	5.0	64.7	29.6	13.5	4.7	11.3	5.9	2.6	0.31	44	2.3
20–27	B_{22gxt}	0.3	4.3	62.6	32.8	18.0	4.5	13.4	5.9	4.5	0.38	45	1.3
27–35	B_{22gxt}	1.4	6.3	65.3	27.0	13.6	4.5	[2]	4.7	5.1	[2]		0.9
35–43	B_{23gxt}	5.1	13.7	61.9	19.3	8.2	4.6	7.3	3.3	4.3	0.20	52	0.8
43–56	B_{24t}	0.9	8.4	71.3	19.4	8.0	4.7	6.5	4.0	4.9	0.18	58	0.8
56–61	B_{24t}	3.5	15.7	64.9	15.9	6.7	4.8	5.6	3.1	2.4	0.16	55	1.3
Profile 4, Inceptisol													
0–1	A_1	19.5	29.3	41.2	10.0	1.5	4.5	19.0	4.4	0.8	0.51	21	5.6
1–3	A_1	21.2	29.0	38.6	11.2	2.0	4.7	9.9	1.1	0.3	0.22	14	3.7
3–8	B_{21}	12.4	23.0	51.6	13.0	2.8	4.7	5.9	1.6	0.4	0.14	26	4.0
8–13	B_{21}	15.5	28.8	42.7	13.0	5.1	4.4	7.5	1.7	0.2	0.13	20	8.0
13–26	B_{21}	26.1	44.2	19.8	9.5	3.0	4.4	5.2	1.0	0.2	0.18	21	5.0
26–32	B_{22}	27.4	41.4	22.6	8.6	4.2	4.5	4.5	1.3	1.4	0.17	39	0.9
32–38	B_{23xg}	34.3	37.0	20.3	8.4	2.9	4.7	3.6	1.6	1.1	0.16	45	1.5
38–51	IIB_{24xg}	8.9	22.1	46.2	20.8	4.7	4.4	9.6	1.6	2.6	0.18	31	0.6
51–60	IIIC	32.0	47.1	15.5	5.4	1.2	5.1	11.3	4.9	2.5	0.13	40	2.0
Profile 6, Ultisol													
0–10	A_p	3.9	18.2	61.7	16.2	2.6	6.4	4.2	5.4	1.4	0.23	62	3.9
10–16	B_{21t}	2.5	8.6	66.9	22.0	7.4	5.2	6.2	3.6	1.2	0.16	45	4.0
16–23	B_{21t}	3.0	10.0	65.5	21.5	8.0	4.6	8.9	2.3	0.5	0.17	25	4.6
23–32	B_{22t}	19.7	57.1	13.1	10.1	2.7	4.6	5.9	1.4	0.5	0.15	26	2.8
32–50	B_{23}	10.3	64.5	10.2	15.0	4.6	4.6	7.3	1.2	1.2	0.16	26	1.0
50–62	B_{24}	5.6	59.3	19.6	15.5	6.1	4.6	7.5	0.9	1.9	0.16	21	0.5
62–70	B_3	12.8	63.7	11.5	12.0	4.2	4.6	5.9	0.9	1.3	0.12	28	0.7

[1]Soil samples obtained by scraping coatings from rock fragments.
[2]Sample missing.

The high drainageways with small streams above an elevation of 970 ft are filled by bouldery colluvium to more than a depth of 10 ft where the pipeline crossed them, as at Profile 4. From soil survey work elsewhere in the county, it can be shown that only at sharp breaks in gradient are these small streams excavating bedrock.

DISCUSSION, CONCLUSIONS, AND GLACIAL HISTORY

The evidence found along the pipeline excavation and in the adjacent unglaciated part of Columbiana County indicates that only the ridgetops above 1200 ft are entirely mantled by material developed from underlying rocks.

The Calcutta Silt, a waterlaid deposit, mantles lower benches at 1080 to 1180 ft. A small amount of colluvium over the Calcutta Silt and a buried paleosol formed in bedrock beneath the Calcutta Silt were also found on a bench.

Considerable downward movement of materials on slopes has deposited colluvium in coves, on a very early Pleistocene terrace, and on slopes. Colluvium is thin or lacking on the benches at the bases of steep slopes in the Illinoian till plain and on Illinoian terraces, indicating that the thick colluvium was deposited in pre-Illinoian time.

Pre-existing deeper channels in high drainageways are filled by colluvium, and in these channels, the bedrock is not being reached by down-cutting water except at breaks in gradient. Apparently downward corrasion has not removed colluvium deposited in these channels by a former geological event.

Apparently rock layers ranging from sandstone to coal were plastic enough to have extended horizontally from hillside outcrops, or coherent and distinctive enough to persist in glide, into unconsolidated surficial materials on a terrace, a bench and slopes during the Pleistocene. In some places there is less than 40 ft of overburden on these layers so that probably this extension of bedrock was not due to pressure from weight of overlying rock.

Very early Pleistocene outwash, laminated material, and colluvium mantle a high rock terrace. Lower terraces not in the pipeline traverse have outwash of later glaciations.

Unconsolidated material persists on terrace and bench surfaces through time during which valley walls were removed by downward and lateral stream corrasion. This indicates that lateral stream corrasion, and not geologic sheet erosion, is the primary agent which removes soil material and levels land surfaces in this region.

This study leaves in doubt the reasons explaining why shallow soils formed from siltstone are present on the old ridgetops. This land surface has more gentle slopes than the other surfaces and erosion would be less likely to have removed soil material. Erosion has not removed very early Pleistocene deposits on nearby more sloping, slightly lower, land surfaces. Yet the 1200-ft and higher surface is the oldest, probably by several million years, if it is a remnant of a Tertiary erosion surface (Stout and Lamborn, 1924: 38–40). Weathering would be expected to have formed soil from siltstone to greater than shallow depths during the intervening time. Perhaps an unexpectedly large amount of soil material dissolves during chemical weathering and is carried away by drainage as fast as the siltstone weathers to soil material. The deeper soils on terraces and benches may remain only because there was more unconsolidated material to begin with, and the deeper soils on the ridgetops, formed from red shale, limestone, and black shale, exist because these rocks weather more rapidly and accumulate soil as a residue faster than it dissolves.

Shallow Inceptisols have developed on the 1200 to 1230-ft ridgetops from underlying siltstone. The deep well-drained soil on the 1080 to 1180-ft benches, developed from Calcutta Silt, is an Alfisol-Ultisol intergrade, but the imperfectly drained soil here is an Alfisol. The deep well-drained soil formed from colluvium is an Inceptisol, but the moderately well drained soil is an Alfisol. The well-drained soil developed from very early Pleistocene glacial outwash is an Ultisol, but the moderately well drained associate is an Alfisol. The soils on stream bottomlands are Entisols. Thus, except for the Entisols, the well-drained soils formed from various parent materials in this small area belong to several soil orders, but the less-than-well-drained catenary associates belong to just one soil order—the Alfisols.

The soil parent materials exposed in the pipeline excavation serve to link together a unique series of Pleistocene deposits found at separated locations along Little Beaver and Ohio valleys during soil survey work in the county.

The local pre-glacial land surface of the Allegheny Plateau with ridges at 1200 ft and higher, benches at 1080 to 1180 ft, and stream valleys at 900 to 1000 ft rising

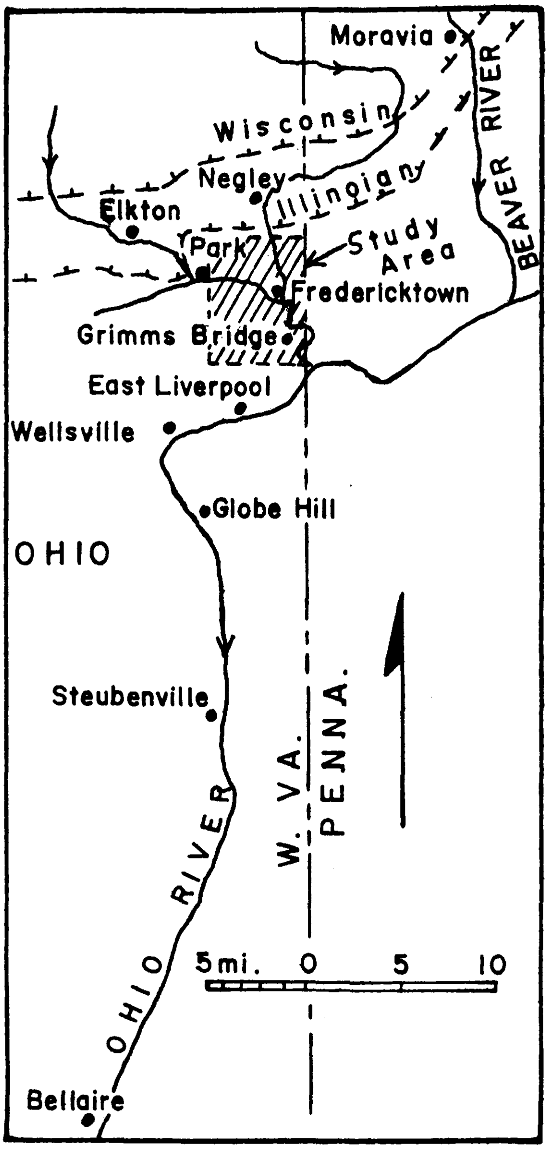

FIGURE 4. The upper Ohio Valley region.

to the south, drained towards the north during the Teays drainage stage (Leverett, 1902; Stout and Lamborn, 1924). A very early or first glaciation of the Allegheny Plateau advanced far enough south, at least to Moravia, Pennsylvania (fig. 4), to block the northward drainage, pond water over the benches, and deposit Calcutta

Silt on pre-glacial surfaces below 1180 ft (Lessig, 1963). The ponded water flowed over and lowered pre-glacial divides to form new southward-flowing Little Beaver Creek and Ohio River. The very early Pleistocene glacial meltwater deposited outwash on the pre-glacial drainage levels, or high terrace, at Negley (fig. 3), on the pipeline traverse (fig. 2), at Fredericktown and Grimms Bridge (fig. 3), and at East Liverpool and Wellsville (Lessig, 1961a). During the first interglacial stage there was entrenchment to 800 ft in the Ohio Valley (Lessig, 1959a) and apparently some along Little Beaver Creek, as for example, west of Grimms Bridge (fig. 3).

A second, or Kansan (?) glaciation invaded the Allegheny Plateau as far south as Elkton (Lessig and Rice, 1962) (fig. 4), but far downstream at Cincinnati it crossed the new Ohio River (Rich, 1956) and probably raised the level of drainage upstream in the Columbiana County area so that laminated material was deposited over the very early Pleistocene outwash on the high terrace to an elevation of 960 ft at Negley (fig. 3), on the pipeline traverse, at Grimms Bridge, and at Wellsville (Lessig, 1961a). At Park (fig. 3), the laminated material is underlain and overlain by alluvium from local rocks. Here on the Middle Fork Little Beaver Creek the very early Pleistocene outwash was not found. When the Kansan (?) ice retreated from the Ohio Valley at Cincinnati, the laminated material was entrenched and the outwash was deposited at Elkton (Lessig and Rice, 1962), Park, Grimms Bridge, the mouth of Little Beaver Creek (fig. 3), East Liverpool (Lessig, 1959c), and Globe Hill (Lessig, 1959a) (fig. 4). Following this, a large amount of colluvium was deposited in coves, on steep slopes, over parts of terraces (Lessig, 1959c) and benches, and in entrenched drainageways (figs. 2 and 3).

The Illinoian glaciation, which followed, extended as far south as the north border of the pipeline study area (White, 1951) (fig. 4) and deposited outwash on a terrace level about 100 ft above drainage along Little Beaver Creek (fig. 3) and the Ohio River (Lessig, 1961b). Wisconsin glaciation terminated several miles farther north (fig. 4) and deposited outwash about 50 ft above present drainage (fig. 3). Thick colluvium was not found over Illinoian and Wisconsin glacial drift.

The soils and soil parent materials in the unglaciated Allegheny Plateau along the pipeline traverse and elsewhere in Columbiana County provide a record of Pleistocene glacial and interglacial events. Study of the differences in soil morphology and parent materials indicates that types of soil formation in the pre-Wisconsin-age well-drained soils is largely controlled by the nature of the parent material.

This study shows that the underlying bedrock is not a reliable guide to the indentification of the parent material of soils below 1200 ft in elevation in this area. It is apparent that the existance of pre-glacial and inter-glacial drainage systems with subsequent blocking by glaciers, and of colluvial action on slopes, can give rise to soils unlike those which are formed from underlying bedrock. Furthermore, soils of different soil orders have developed in close proximity to each other under well-drained conditions and from varying parent materials.

ACKNOWLEDGMENTS

I am indebted to Drs. William A. Rice and Jane L. Forsyth for review and comment on this paper, and to William F. Hale for assistance in field study of soil profiles.

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